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(with statement of verification of translation)

Verification of Translation

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declare as follows:

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4 April 2006
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A collector with fastening devices for fastening mirror shells

The invention relates to a collector for projection printing installations which are operated in a scanning mode along a scanning direction with a wavelength ≤ 193 nm, preferably ≤ 126 nm, more preferably with wavelengths in the extreme UV region. Said collector receives light from a light source and illuminates a region in a plane to be illuminated. The collector comprises a plurality of rotationally symmetrical mirror shells which are arranged within each other about a common rotational axis.

The invention further also provides an illumination system with such a collector, a projection printing system with an illumination system in accordance with the invention as well as a method for illuminating microstructures.

Nested collectors for wavelengths ≤ 193 nm, especially wavelengths in the region of X-rays, have become known from a plurality of documents.

US 5,768,339 shows a collimator for X-rays, with the collimator comprising several paraboloidal reflectors. The collimator according to US 5,768,339 is used to form into a parallel beam a ray beam of an X-ray source radiated in an isotropic way.

A nested collector for X-rays has become known from US-A-1865441 which is used – as in the case of US 5,768,339, to collimate isotropic X-rays into a parallel beam of rays.

US 5,763,930 shows a nested collector for a pinch plasma light source which is used to collect the radiation emitted by a light source and to focus the same in a waveguide.

US 5,745,547 shows several arrangements of multi-channel optics which are used for concentrating the radiation of a source, especially X-rays, in a point.

In order to achieve an especially high transmission efficiency, the invention according to US 5,745,547 proposes elliptically shaped reflectors.

An arrangement has been disclosed in DE 30 01 059 C2 for the use in X-ray lithography systems which comprises parabolic mirrors arranged in a nested way between X-ray source and mask. These mirrors are arranged in such a way that the diverging X-rays are shaped into a parallel extending output aigrette.

The arrangement according to DE 30 01 059 is merely used for achieving a favorable collimation for X-ray lithography.

The arrangement of nested reflectors as known from WO 99/27542 is used in an X-ray proximity lithography system in such a way that light of a light source is refocused so that a virtual light source is formed. The nested shells can have an ellipsoidal shape.

A nested reflector for high-energy photon sources is known from US 6,064,072 which is used to shape the diverging X-rays into a beam of rays extending parallel.

WO 00/63922 shows a nested collector which is used to collimate the neutron beam.

A nested collector for X-rays is known from WO 01/08162 which is characterized by a surface roughness of the inner reflective surface, the individual mirror shells of less than 12 Å rms. The collectors shown in WO 01/08162 also comprise systems with multiple reflections, especially also Wolter systems, and are characterized by high resolution, as is also demanded in X-ray lithography for example.

In addition to resolution, high requirements are also placed on evenness, uniformity and telecentricity with respect to illumination lens systems for EUV lithography, such as in DE 199 03 907 or WO 99/57732.

It is the object of the invention to provide a collector for an illumination system for microlithography with wavelengths ≤ 193 nm, preferably ≤ 126 nm, more preferably for wavelengths in the EUV range, which collector has a sufficient mechanical stability and a high light efficiency. Impairments in the uniformity of the illumination in the field plane are to be avoided by the holding devices of the collector.

This object is achieved in accordance with the invention in such a way that in a nested collector which illuminates a plane on the image side and comprises a plurality of mirror shells which are rotationally symmetrical about a rotational axis the individual mirror shells are held by fastening devices, with the fastening devices comprising support spokes extending in the radial direction. The support spokes are arranged in such a way that when they are projected into the plane to be illuminated on the image side they are inclined relative to the y-direction of the local system of coordinates in the plane on the image side. In this respect the y-direction is the direction of the local system of coordinates which is parallel to the scanning direction of a projection printing system for example which is operated in a scanning mode.

It generally applies that the mechanical stability is improved the more support spokes are used. In order to keep the loss of light by vignetting as low as possible by the support spokes extending in the radial direction, it is advantages when the spokes are provided with a very narrow arrangement. Especially preferably the support spokes have a shape which tapers in the radial direction towards the rotational axis. This leads to the advantage that a high stability is achieved and the loss of light by shading effects is limited because the percentage rate of shadowed area relative to the circumference of a shell is always approximately the same. This will be achieved when the width of the support spoke increases proportionally to the distance from the common rotational axis.

Preferably, the support spokes comprise grooves in which the individual mirror shells can be inserted for fixing. An especially stable embodiment is obtained when the mirror shells are glued together with the support spokes in the grooves.

The support spokes extend in the radial direction in the plane opened in the x- and y-direction. The common rotational axis is perpendicular to the plane as opened by the x- and y-direction.

The mechanical stability of the collector is increased even further when in addition webs are provided which extend substantially parallel to the common rotational axis.

In order to keep any shading of the light by the extension of the spokes as low as possible, it is advantageously provided that the spokes taper in the direction of the rotational axis of the collector towards the plane to be illuminated.

In accordance with the invention, the influences of the mechanical holding devices on the uniformity of the illumination in the field plane can be kept low by a clever arrangement of the support spokes. This is achieved in such a way that the support spokes are arranged in such a way that when they are projected into the plane to be illuminated on the image side, they are inclined relative to the y-direction in the plane to be illuminated on the image side. It is especially advantageous when at least one support spoke of the plurality of support spokes of the collector extends parallel to the x-direction, i.e. perpendicular to the scanning direction, in the plane to be illuminated on the image side in which or close to which the first optical element is arranged with first raster element. The images of all first raster elements of the first optical element are superimposed in the field plane and produce the illuminated field in the field plane.

It is especially advantageous when the raster elements are arranged on the first optical element in such a way that no raster element is arranged in the region of the shading or vignetting of a spoke extending in the x-direction, because the first raster elements which are also designated as field facets and are shadowed completely by a supporting spoke cannot contribute anything to the illumination of the field in the field plane.

If further support spokes are provided, then it is especially advantageous when the further support spokes are arranged in such a way that the shadings which are caused by said support spokes by the projection into the plane to be illuminated on the image side extend in such a way that the plurality of the first raster elements which are arranged on the first optical element are each intersected at different locations and are thus vignetted. The influence of the shading of the individual field facets by the supporting spokes on the uniformity of the field in the field plane is low because the images of the plurality of the field facets are superimposed in the field plane and each field facet is shaded at different locations. This means however, that when different field facets are vignetted at different locations, the shadings will only have a minor effect

because all other field facets at this location are illuminated completely. The uniformity of the illumination in the field plane is thus impaired only to a low extent.

A uniformity of $\Delta SE(x)$ of better than 1.5% can thus be achieved in a system with six support spokes.

In addition to the collector and the illumination system, the invention also provides an EUV projection printing system as well as a method for producing microelectronic components.

The invention will now be described below by reference to examples shown in the drawings, wherein:

Fig. 1 shows a schematic diagram with a fastening device in accordance with the invention;

Fig. 2 shows a three-dimensional view of the fastening device of a shell of a collector in accordance with the invention with cooling rings and spokes and webs;

Fig. 3 shows a first element with raster elements which is arranged in the plane of the collector to be illuminated in the image side;

Fig. 4 shows a vignetting by the support spokes of a fastening device in accordance with the invention in the plane of the first optical element with first raster elements;

Fig. 5a shows a three-dimensional view of a first embodiment of a spoke of a holding device;

Fig. 5b shows a three-dimensional view of a second embodiment of a spoke of a holding device;

Fig. 6 shows a schematic diagram of a projection printing system for the production of microelectronic components;

Fig. 7 shows a system of coordinates of all optical components of the illumination system of the EUV projection printing system pursuant to fig. 6;

Fig. 8 shows an 8-shell nested Wolter system;

Fig. 9 shows a diagram for explaining the coordinates of a collector shell designed as a collector system with two reflections;

Fig. 10 shows the superimposition of the images of the first raster elements in the field plane;

Fig. 11 shows the course of the scan-integrated energy SE(x);

Figs. 12a – 12c show different arrangements of the spokes in the x-y plane.

Fig. 1 shows an embodiment of a collector nested in accordance with the invention with two mirror shells 1004.1, 1004.2 which are arranged within each other and in which the ring aperture elements through which the light of the light source 1 is received by the collector have a gap 1000 between the object-side ring aperture elements 1002.1 and 1002.2 of the first mirror shell 1004.1 and the second mirror shell 1004.2. The ring elements 1003.1, 1003.2 on the image side, into which the light received from the light source 1 is guided into the plane 3 on the image side to be illuminated, are directly adjacent, so that in the image space, i.e. the plane to be illuminated on the image side, there is no gap with the exception of the central shading 1005. Cooling devices 1006.1, 1006.2, 1006.3 are arranged in the illustrated collector in the unused region between the two mirror shells 1004.1, 1004.2 and within and without the collector. The mirror shells 1004.1, 1004.2 end approximately in a plane 1008 and are grasped in this plane 1008 in accordance with the invention by a spoke wheel of which one spoke 1010 is shown. Every mirror shell 1004.1, 1004.2 of the illustrated embodiment comprises two mirror segments, namely a first mirror segment 1007.1, 1007.2 with a first optical surface and a second mirror segment 1009.1, 1009.2 with a second optical surface which are arranged successively without a gap. The first mirror segments 1007.1,

1007.2 are in the present example segments of hyperboloids and the second mirror segments 1009.1, 1009.2 are segments of ellipsoids.

As is shown in the meridional sectional view in fig. 1, the inner and outer edge beams 1016.1, 1016.2, 1018.1, 1018.2 of the respective mirror shell or the connecting lines associated with the same between the source 1, the image of source 5, the shell ends 1024.1, 1024.2 and in systems with two mirror segments additionally the transitional region between the first 1007.1, 1007.2 and the second mirror segment 1009.1, 1009.2 define an optically used region or a so-called beam hole through which the radiation flux flows from the object or from the light source 1 to the image 5 of the light source. A meriodional section or a meridional plane is the plane which comprises the rotational axis RA. An unused region 1032 is now situated between the used regions 1030.1, 1030.2 of at least two mirror shells 1004.1, 1004.2 which are arranged within each other.

In the unused region 1032 between two mirror shells 1004.1, 1004 it is possible to arrange further components of the nested collector without influencing the radiation flux from the light source 1 to the image of the light source 5. Examples for such components are detectors or output mirrors which deflect light to detectors or non-optical components such as heat shields or cold traps. Cooling devices 1006.1, 1006.2, 1006.3 can be in direct contact with the rear sides of the collector shells. The arrangement of electrodes or magnets for deflecting charged or magnetic particles is also possible. Electric conductors or conduits for feeding or removing coolant can only be provided in the case of slight shading of the collector aperture on the image side, i.e. the illuminated region in the picture-side plane outside of the collector. Preferably, these lines 1044 are guided in the region of the shadows of the spokes 1010 of the spoke wheel with spokes 1010. The spoke wheel is aligned in accordance with the invention in the x-direction, i.e. perpendicular to the scanning direction. The shells of the nested collector per se are provided in a rotationally symmetrical manner about the rotational axis z. Obviously, further cooling elements or detectors can also be arranged in regions outside of the outermost shell 1004.2 or the central shading 1052. A stop can also preferably be arranged in the region of the central shading.

If the collector in accordance with the invention as shown in fig. 1 is used in an illumination system, the first optical element of the illumination system with first raster elements which are also designated as first field facets is arranged in or close to the plane 3 to be illuminated on the image side.

Grooves can be incorporated in the spokes of the spoke wheel, e.g. they can be milled in. The collector shells can be embedded in said grooves. In this way it is possible to grasp the mirror shells with the fastening device in accordance with the invention, e.g. in such a way that the mirror shells are glued in the groove.

Fig. 2 shows a further development of the embodiment of the invention. In the embodiment shown in fig. 2 the holding device is shown representatively for a single mirror shell. The holding device comprises two spokes 1204.1, 1204.2 in the x-y plane for holding the individual mirror shells and additional webs 1202.1, 1202.2. Each of the webs is fastened to a spoke of the spoke wheel. The webs contribute to the further mechanical stabilization of the collector. Fig. 2 further shows cooling devices for cooling the collector shell, which devices are arranged as cooling rings which run around the full circumference of the collector.

The cooling rings 1200.1 and 1200.2 are arranged in the unused space between two mirror shells of a collector with two segments per mirror shell for example. Such a double-shell Wolter collector is shown in fig. 1 for example in a meridional sectional view. The cooling rings 1200.1, 1200.2 are held on holding structures or webs 1202.1, 1202.2 which extend in the shadow of the spokes of the spoke wheel and extend in the direction of the rotational axis. The connection of the cooling rings 1200.1 and 1200.2 with the holding webs 1202.1., 1202.2 can be made via a soldered connection for example. This guarantees a favorable mechanical and thermal contact. The webs are preferably made of a material with favorable thermal conductivity, e.g. copper, and are easy to solder. The cooling rings 1202.1, 1202.2 are also preferably made of a material which favorable thermal conductivity such as copper or steel.

As already mentioned above, the bridges 1202.1, 1202.2 are fastened to the two spokes 1204.1, 1204.2 of the spoke wheel which grasps and fixes the individual mirror

shells, e.g. by means of screws. The spokes extend in the radial direction, i.e. in a direction perpendicular to the rotational axis and perpendicular to the scanning direction.

Fig. 3 shows the arrangement of the first raster elements which are designated as field facets on the first optical element with first raster elements which is arranged in the plane 3 to be illuminated by the collector. The first optical element with first raster elements is situated in a plane opened up by the local x- and y-direction. The plane of the field honeycomb mirror as opened up by the local x- and y-direction does not stand perpendicular to the rotational axis of the collector and thus does not exactly correspond to the plane 3 of fig. 1 to be homogeneously illuminated. Slight angles of inclination change nothing in the discharge and only lead to a slight distortion of the illumination. The first raster elements 1500 are arranged in twelve mutually spaced blocks 1502.1, 1502.2, 1502.3, 1502.4, 1502.5, 1502.6, 1502.7, 1502.8, 1502.9, 1502.10, 1502.11, 1502.12. There are no raster elements 1500 in the region which is not illuminated by the central shading 1504 of the collector. Furthermore, no raster elements are arranged in the region of the first optical element with raster elements which is vignetted in the plane to be illuminated on the image side by spokes of the spoke wheel extending parallel to the x-direction. The vignetting in the plane to be illuminated in which the optical element with first field facets is arranged is shown in fig. 4. The spoke wheel which leads to the vignettings in the x'-y' plane of the first optical element as shown in fig. 4 comprises two supporting spokes 2000.1 and 2000.2 extending parallel to the x'-direction in the local plane of the collector as well as four further supporting spokes 2002.1, 2002.2, 2002.3, 2002.4 which extend in a direction in the local x'-y' plane of the collector which is not parallel to the x'-direction in the local x'-y' plane.

As already mentioned above, the planes opened up by the local x'- and y'-directions of the collector and the field honeycomb mirror do not coincide exactly. Instead they are mutually inclined relative to each other at low angles of inclination. This does not change anything in the general discharge of the arrangement of the support spokes and leads to only mirror distortions of the illumination.

The further supporting spokes 2002.1, 2002.2, 2002.3, 2002.4 are arranged in such a way that the vignetting as is caused by them in the x'-y' plane in which the first raster elements are arranged will shadow the individual first raster elements at different locations. As a result, the field facets of block 1502.2 for example are shadowed substantially in the middle, whereas the field facets of the blocks 1502.11 are merely shadowed at the edge and in the block 1502.3 merely one is shadowed at the edge out of the four field facets.

No field facet is shadowed off in the block 1502.1. Since in the present case the blocks of the first raster elements are arranged on the first optical element in a manner symmetrical both with respect to the y'-axis as well as x'-axis, the same considerations apply with respect to the blocks which are symmetrical to the blocks 1502.1, 1502.2, 1502.3 and 1502.11. Since, as was already explained above, the individual field facets (when symmetries are not considered) are vignetted by the support spokes at different locations in the plane to be illuminated in which the optical element is arranged, the loss of light by these shadings in the field plane in which the images of all field honeycombs are mutually superimposed will substantially average themselves out, so that as a result of the arrangement in accordance with the invention the uniformity of the illumination of the field in the field plane is influenced to an only very low extent. This is explained in closer detail with reference to figs. 11 and 12 a to c.

As is shown by the shape of the shadings in the plane to be illuminated, the spokes of the spoke wheel which do not extend parallel to the x'-axis are arranged (as shown in the illustrated embodiment) in a manner tapering in the direction towards the rotational axis of the collector which is situated in the region of the central shading. This leads to the advantage that relating to the circumference a similar amount of light is shaded on each shell.

Figs. 5a and 5b show a single spoke of the holding device as shown in fig. 2 in a three-dimensional view. An x-, y-, z-coordinate system is shown, with the spoke having an extension in the z-direction along the direction of the common rotational axis RA of the plurality of mirror shells. The drawing further shows the light source 1 as well as a mirror

shell or the first the mirror shell 1004.1 of the collector according to fig. 1 and the beam path of a beam of rays 3000 from the light source 1 to the source image 5.

Both in the embodiment according to fig. 5a as well as 5b the spoke shows in the x-y sectional view a shape tapering in the radial direction as described in fig. 4.

If the spoke (as is described in fig. 5a) is not provided with a tapering configuration, the boundary rays 3002.1, 3002.1 of a beam of rays 3000 which are reflected from the collector shell 1004.1 are vignetted, with the collector shell 1004.1 being fastened to a groove (not shown) of the spoke. The boundary rays 3002.1, 3002.2 of the beam of rays are defined by the extension of the spoke in the x-direction for the respective mirror shell.

The boundary rays 3004.1, 3004.2 which are reflected and vignetted on the mirror shell 1004.1 by a spoke extending in the z-direction are shown in fig. 5a in a dot-dash line.

If (as is shown in fig. 5b) the spoke is provided with a tapering arrangement in the direction of the light, i.e. in the z-direction, a shading of the boundary rays 3004.1, 3004.2 of the beam of rays 3000 as reflected by the mirror shell 1004.1 can be avoided. The boundary rays are defined as in fig. 5a. In the case of a tapering arrangement as shown in fig. 5b, the spoke tapers in the profile from the object-side aperture which receives the light of the light source 1 to the image-side aperture in which the light is guided in the direction towards the plane 3 to be illuminated and the image of the light source 5. In the profile, the spoke shows a thickness d_1 in the region of the object-side aperture and a substantially lower thickness d_2 on the exit-side end of the collector.

Fig. 6 shows a schematic view of a projection printing system for the production of microelectronic components for example in which the invention may be used.

The projection printing system as shown in fig. 6 comprises a light source 1 as well as a nested collector 30 with 8 shells for illuminating a plane 103. The configuration of the collector is shown in figs. 8 and 9 and the data are shown in table 2. The plane mirror 300 in the beam path between the nested collector and before the intermediate focus Z

can be configured as a spectral filter with a diffraction angle of 2° between 0^{th} and used diffraction order. The first optical element 102 comprises 122 first raster elements with an extension of 54mm x 2.75 mm each. The second optical element 104 comprises 122 of second raster elements which are associated with the first raster elements and which have a diameter of 10 mm each. The optical elements 106, 108 and 110 are substantially used to shape the field in the object plane 114. All location information of the optical components in table 1 relate to the reference coordinate system in the object plane 114 of the project printing system. A structured mask (not shown) is situated in the object plane 114 which is projected by means of a projection lens 126 onto the object to be exposed in the plane 124. The rotation about the angle α about the local x-axis of the local coordinate systems associated with the respective optical component is obtained after a translatory displacement of the reference coordinate system to the place of the local coordinate system. The parameters of the optical components of the illumination system of the project printing system according to fig. 6 are stated in table 1. The illumination system of the projection printing system as shown in fig. 6 comprises the optical components from the light source 1 to the object plane 114. With respect to its principle, the illumination system is a double-faceted illumination system as disclosed in US 6,198,793 B1, the content of which shall be fully included in the present application. Table 1 states the positions of the vertexes of the individual optical elements relating to the object plane 114 and the rotational angles α of the coordinate systems about the x-axis. Right-handed coordinate systems and clockwise rotation are further used. In addition to the local coordinate systems of the optical components, the local coordinate systems of the intermediate focus Z and the entrance pupil E are stated. The field-forming mirror 110 consists of an extra-axial segment of a hyperboloid of rotation. The coordinate systems for all optical elements (as described in table 1) of the illumination system of the projection printing system according to fig. 6 (with the exception of collector 30) are shown in fig. 7. All optical elements are provided with the same reference numerals as in fig. 6.

The system is designed for a field radius of 130 mm at an illumination aperture of NA = 0.03125 in the object plane 114, i.e. on the reticle, according to a filling degree of σ = 0.5 in the entrance pupil E of a subsequent 4:1 projection objective with an aperture NA = 0.25 in the plane 124 of the object to be exposed.

The reticle can be moved in the shown direction 116 in the projection printing system which is designed as a scanning system.

The exit pupil of the illumination system is illuminated in a substantially homogeneous manner. The exit pupil coincides with the entrance pupil E of the downstream projection objective 126. The entrance pupil is located at the point of the intersection of the principal ray with the optical axis of the projection objective, which principal ray is reflected by the reticle.

The projection objective 126 comprises six mirrors 128.1, 128.2, 128.3, 128.4, 128.5, 128.6 for example according to the US patent application 09/503640 and projects the reticle in the object plane 114 onto the object 124 to be exposed.

Table 1: Design data of the illumination system of the projection printing system according to fig. 6

Position	Y	Z	α	Bending radius at vertex	Conical constant
Light source 1	2148.137	-1562.205	70.862	- no mirror surface -	
Plane mirror or spectral filter 200	1184.513	-1227.797	147.434	Plane	
Intermediate focus Z	883.404	-893.382	42.000	- no mirror surface -	
First faceted optical element 102	302.599	-248.333	36.000	-898.54	Spherical
Second faceted optical element 104	773.599	-1064.129	214.250	-1090.15	Spherical
Mirror 106	126.184	-250.216	31.500	288.1	Spherical
Mirror 108	372.926	-791.643	209.600	-855.8	Spherical
Vertex of mirror 110	-227.147	118.541	-4.965	-80.5	-1.1485701

Object plane 114	0.000	0.000	0.000	Plane
Entrance pupil E	-130.000	-1236.857	0.000	- no mirror surface -

In order to reduce the system length, the image-side aperture of the nested collector 30 which has a structure as in fig. 8 is increased to NA = 0.115, for which reason the configuration as a Wolter system is especially advantageous. The aperture on the object side is NA ~ 0.71. A plane mirror 300 for folding the system is inserted in addition after the collector 30 in order to provide construction spaces for mechanical and electronic components in the object plane 114 in which the wafer stage is situated. The entire optical system is less than 3 m long and less than 1.75 m high.

The plane mirror 300 is configured in the present embodiment as a diffractive spectral filter, i.e. it is realized by a grating. In combination with the stop 302 close to the intermediate image Z of the source it is thus possible to hold back undesirable radiation with wavelengths for example which are substantially higher than the desired wavelength (which in the present case is 13.5 nm) from entering the part of the illumination system which is situated behind the stop 302.

The stop 302 can also be used to spatially separate the space 304 which comprises the light source 1, the nested collector 3 as well as plane mirror 300 which is configured as a grating from the downstream illumination system 306. If both spaces are separated by the introduction of a valve close to the intermediate focus Z, a separation by pressure is also possible. A spatial or pressure separation can prevent that impurities caused by the light source will reach the illumination system situated behind the stop 302.

The collector 30 of the projection illumination system according to fig. 6 is shown in fig. 8 and has a distance of 1500 mm between source 1 and the intermediate image of source Z, an aperture of ~ 0.72 on the object side and an aperture of ~ 0.115 on the image side. The angle of incidence relative to the surface tangent of the maximum ray in the embodiment according to fig. 8 is 11.9°.

Fig. 8 further shows a stop 180 which is disposed in the interior of the innermost mirror shell. Nested reflective collectors necessarily comprise a central shading due to the finite size of the mirror shells, i.e. below a certain aperture angle NA_{min} the radiation of

the source cannot be received. The stop 180 ensures that light reaching directly through the shell will not reach the downstream illumination system as stray light.

The stop 180 is situated 78 mm behind the source for example and has a diameter of 30.3 mm according to an aperture obscuration of NA_{obs} ~ 0.19. The aperture obscuration on the image side is accordingly NA'_{obs} ~ 0.0277.

The characteristic coordinates of a Wolter system comprising two segments, e.g. the first segment 200.1 and the second segment 200.3 of the first mirror shell 200, are shown in fig. 9 in an exemplary manner for the mirror shells 200, 202, 204, 205, 206, 207, 208, 209 of the collector according to fig. 8. ZS designates the z-position of the surface vertex relating to the position of the light source 1. ZV and ZH relate to the initial and end position of the first segment 200.1, which is a hyperboloid, relating to the position of the surface vertex ZS. The reference numerals ZS, ZH and ZV are used in an analogous manner for the second segment 200.3 of the mirror shell which is an ellipsoid.

The design data of the collector according to fig. 8 are obtained from the following table with the radii of curvature R and the conical constant K of the respective mirror segment and the given definitions. Ruthenium was chosen as the coating for the mirror shells.

Table 2: Design data of the collector according to fig. 8

	Hyperboloid				
Shell	R [mm]	K	ZS [mm]	ZV [mm]	ZH [mm]
1	1.5866	-1.0201	-0.79	108.99	185.86
2	2.3481	-1.0286	-1.17	107.92	183.90
3	3.5076	-1.0399	-1.74	107.56	182.35
4	5.0414	-1.0571	-2.49	105.05	179.53
5	7.2534	-1.0814	-3.56	102.83	177.68
6	10.4354	-1.1182	-5.07	99.95	175.90
7	15.0523	-1.1755	-7.22	94.87	173.09
8	22.3247	-1.2660	-10.50	88.88	169.39
	Ellipsoid				

Shell	R [mm]	K	ZS [mm]	ZV [mm]	ZH [mm]
1	2.3724	-0.9971	-160.94	349.66	433.46
2	3.3366	-0.9960	-168.17	353.68	440.17
3	4.6059	-0.9945	-181.56	363.50	454.10
4	6.4739	-0.9923	-184.74	364.03	457.33
5	9.0813	-0.9893	-189.80	366.19	463.15
6	12.8589	-0.9849	-193.20	365.14	466.03
7	18.4682	-0.9783	-195.28	362.33	470.02
8	26.8093	-9688	-202.36	362.94	480.72

The embodiment of the Wolter system according to fig. 8 with eight shells is chosen in such a way that all shells end approximately in one plane 181. In this way all shells can be grasped in one plane 181.

The support spokes in accordance with the invention are used for holding the shells. The support spokes provide stability to the nested collector with a plurality of mirror shells.

Fig. 10 shows the superimposition in the field plane of the images of the first raster elements which are also designated as field honeycombs. The superimposition of the images 3500 of the first raster elements lead to an annular field in the field plane. The field plane is opened up by the x-y plane. Here the y-direction is parallel to the scanning direction and the x-direction is perpendicular to the scanning direction of a scanner-type projection printing system. An intensity I(x,y) is assigned to each field point in the x-y plane.

A characteristic variable for scanner-type projection printing systems is the scanning energy in the scanning direction, i.e. the scanning energy integrated in the y-direction.

The scan-integrated energy *SE(x)* is obtained for a field with an intensity distribution I(x,y) by integrating the intensity distribution in the scanning direction, i.e.:

$$SE(x) = \int I(x,y)dy.$$

The uniformity error is given by

$$\Delta SE = \frac{SE_{\max} - SE_{\min}}{SE_{\max} + SE_{\min}}$$

with SE_{max} or SE_{min} designating the maximum or minimum value of the scan-integrated energy $SE(x)$ within the illuminated field having an extension in the x- and y-direction and a shape as shown in fig. 10.

Fig. 11 shows the course of the scan-integrated energy SE(x) for a field as shown in fig. 10.

Curve 4100 is obtained for the scan-integrated energy SE(x) in the field plane when the collector has a total of six spokes, with two spokes extending perpendicular to the x-direction and four spokes extending under an angle of 45 degrees to the x-direction. A top view in the local x-y plane of such a collector is shown in fig. 12a. Reference numerals 4000.1 and 4000.2 designate the two spokes extending in the y-direction and reference numerals 4002.1, 4002.2, 4002.3, 4002.4 designate the four spokes inclined by an angle α=45° relative to the y-direction. The uniformity error ΔSE(x), as defined above, is merely 1.5%.

Reference numeral 4102 designates the progress of the scanning energy SE(x) in the field plane in the case that the collector comprises six spokes, with two spokes 4000.1, 4000.2 extending in the y-direction and the four spokes 4002.1, 4002.2, 4002.3, 4002.4 being inclined under an angle of 80° relative to the y-axis. Such an arrangement is shown in fig. 12b. The uniformity error ΔSE(x) is in such a case 4.6%.

Reference numeral 4104 designates the progress of the scanning energy SE(x) in the field plane in the case that the collector comprises six spokes, with two spokes 4000.1, 4000.2 extending in the x-direction and the four spokes 4002.1, 4002.2, 4002.3, 4002.4 being inclined under an angle of 30° relative to the y-axis. Such an arrangement is

shown in fig. 12c. The uniformity error $\Delta SE(x)$ is in such a case 8.3%. As is shown from the previous example, the uniformity of the illumination in the field plane can be influenced by the arrangement of the support spokes.

In all cases the local coordinate system in the collector plane substantially coincides with the local coordinate system of the first optical element with raster elements as is shown in fig. 3 for example.

The invention thus provided for the first time a collector with a fastening device for a plurality of rotationally symmetrical mirror shells, which collector is characterized on the one hand in that it offers a high stability and on the other hand that as a result of the arrangement of the spokes the evenness of the field illumination in the field plane in which a mask or reticle is arranged will be influenced to an only very low extent.

CLAIMS:

1. A collector for a projection printing system which is operated in a scanning mode along a scanning direction with a wavelength ≤ 193 nm, preferably ≤ 126 nm, more preferably with wavelengths in the extreme UV region, with the collector receiving light from a light source on the object side and illuminating a region in a plane on the image side which is opened up by a local coordinate system, with the y-direction of the local coordinate system being parallel to the scanning direction and the x-direction being perpendicular to the scanning direction, with the collector comprising:

1.1 a plurality of rotationally symmetrical mirror shells (1004.1, 1044.2), each comprising at least one mirror segment (1007.1, 1007.2) comprising a first optical surface area, with the mirror shells being arranged within each other about a common rotational axis (RA), with

1.2 the collector comprising fastening devices for fastening a plurality of rotationally symmetrical mirror shells, and the

1.3 fastening devices comprise support spokes (1010, 1204.1, 1204.2, 1204.3, 1204.4, 2001.1, 2001.2, 2002.1, 2002.2, 2002.3, 2002.4) which extend in the radial direction of the rotationally symmetrical mirror shells, characterized in that

1.4 the support spokes are arranged in such a way that when they are projected into the plane to be illuminated on the object side they are inclined relative to the y-direction of the local coordinate system in the plane on the image side.

2. A collector as claimed in claim 1, characterized in that at least one part of the support spokes (2001.1, 2001.2, 2002.1, 2002.2, 2002.3, 2002.4) have a shape tapering in the radial direction towards the rotational axis.

3. A collector as claimed in one of the claims 1 or 2, characterized in that the support spokes comprise grooves into which the individual mirror shells are embedded.

4. A collector as claimed in one of the claims 1 to 3, characterized in that the support spokes taper in the direction of the rotational axis of the collector towards the plane to be illuminated.

5. A collector as claimed in one of the claims 1 to 4, characterized in that at least one spoke (2000.1, 2000.2) of a plurality of spokes of the collector extends parallel to the local x-direction in the plane (3) to be illuminated on the image side when they are projected into the plane to be illuminated on the image side.

6. An illumination system for a projection printing system which is operated in a scanning mode along a scanning direction with a wavelength ≤ 193 nm, preferably ≤ 126 nm, more preferably with wavelengths in the extreme UV region, for illuminating a field in a field plane (114), with the field having an extension parallel to the scanning direction and an extension perpendicular to the scanning direction, characterized in that the collector is a collector according to one of the claims 1 to 5 and the illumination system comprises at least one first optical element (102) with raster elements which is arranged in the plane (3) to be illuminated on the image side.

7. An illumination system as claimed in claim 6, characterized in that each support spoke (2002.1, 2002.2, 2002.3, 2002.4) which does not extend parallel to the local x-direction when it is projected into the plane in which the first optical element is arranged with first raster elements is arranged in such a way that its projection into said plane intersects the plurality of the first raster elements of the first optical element at different locations on the first raster elements and thus vignets the same.

8. An EUV projection printing system with

8.1 an illumination system according to one of the claims 7 to 10;

8.2 a mask which is illuminated by the illumination system;

8.3 a projection lens (126) for projecting the mask onto

8.4 a light-sensitive object (124).

9. A method for producing microelectronic components, especially semi-conductor components, with an EUV projection printing system according to claim 11.

P 15990 WO

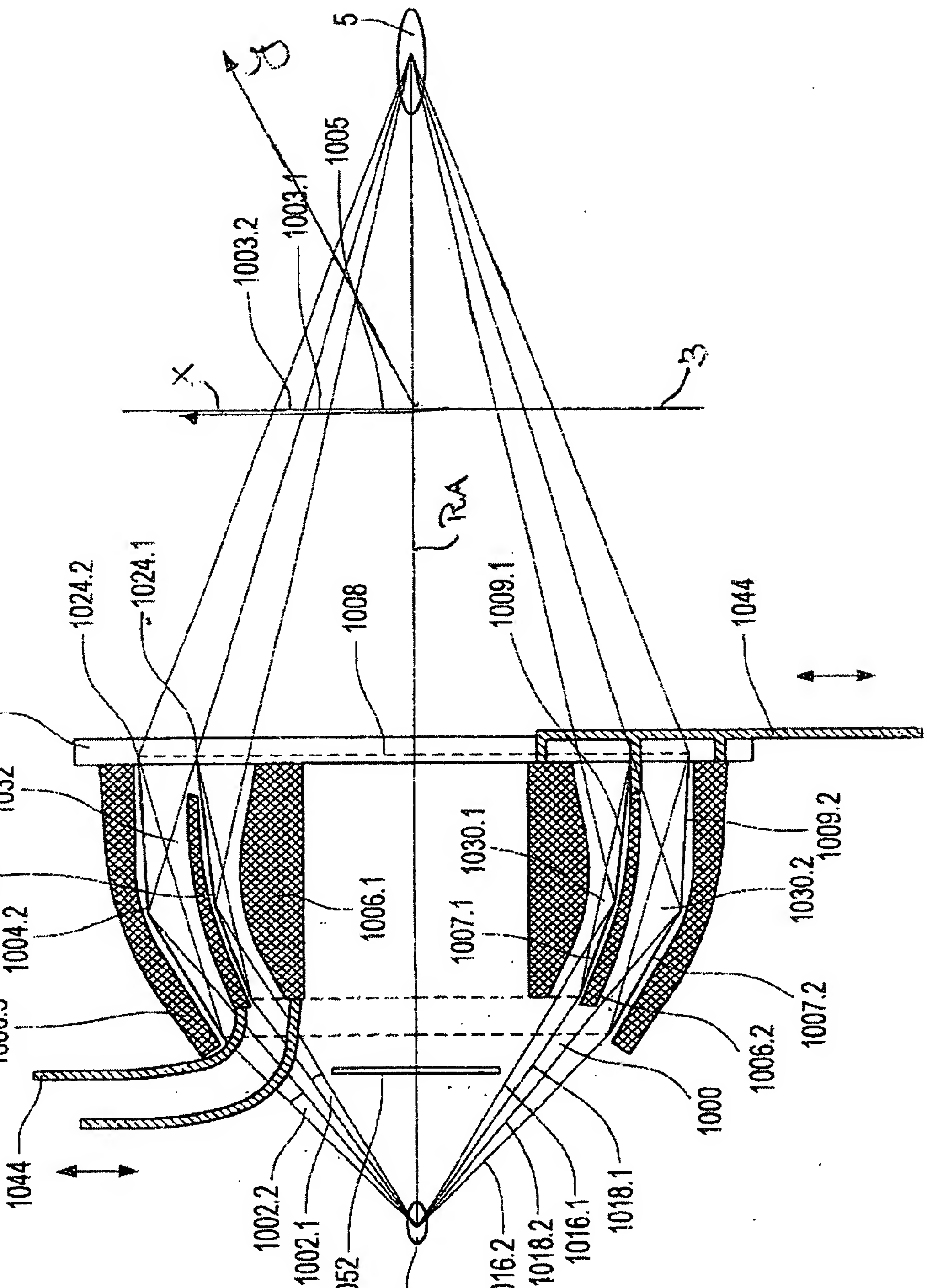
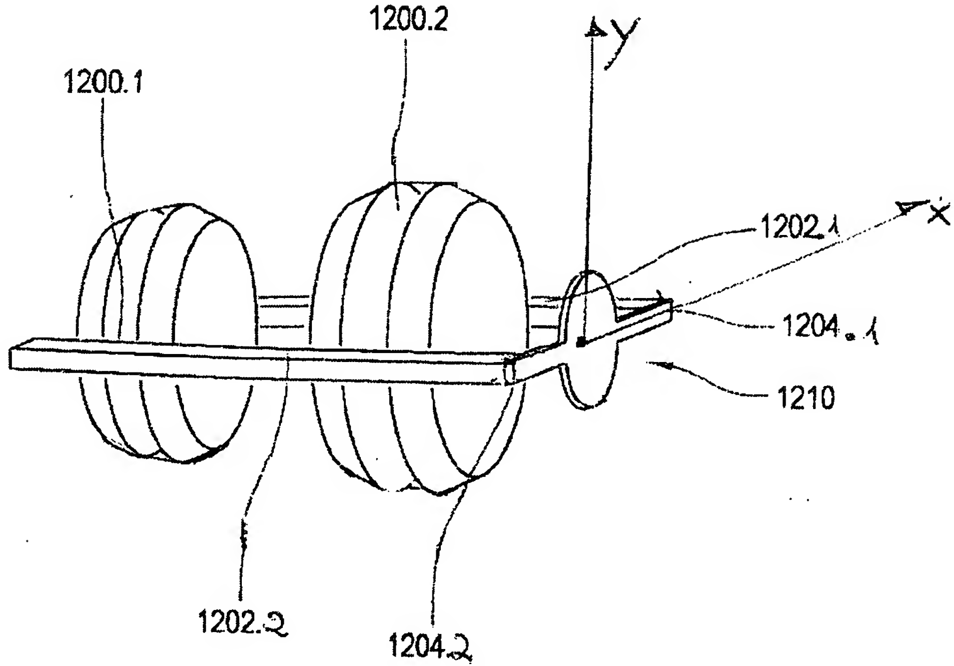
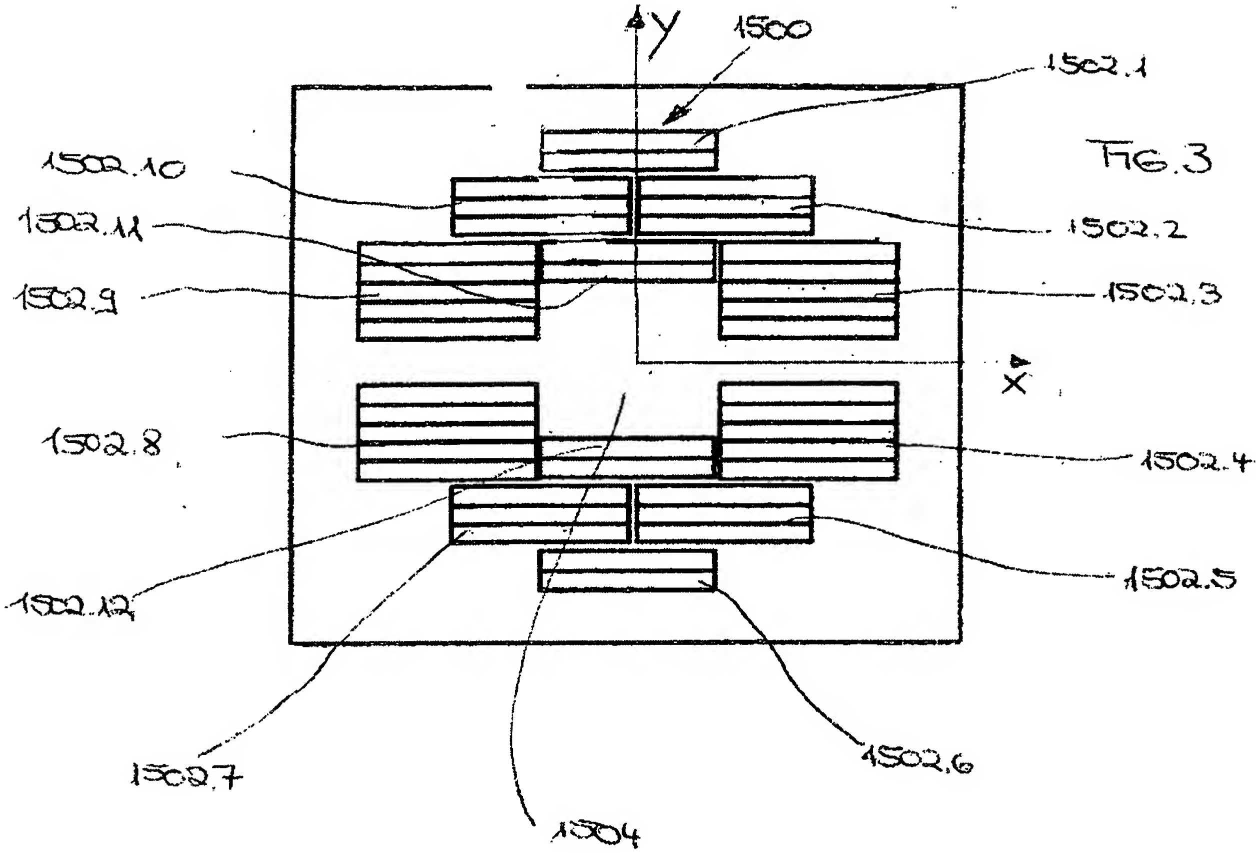


Fig. 1

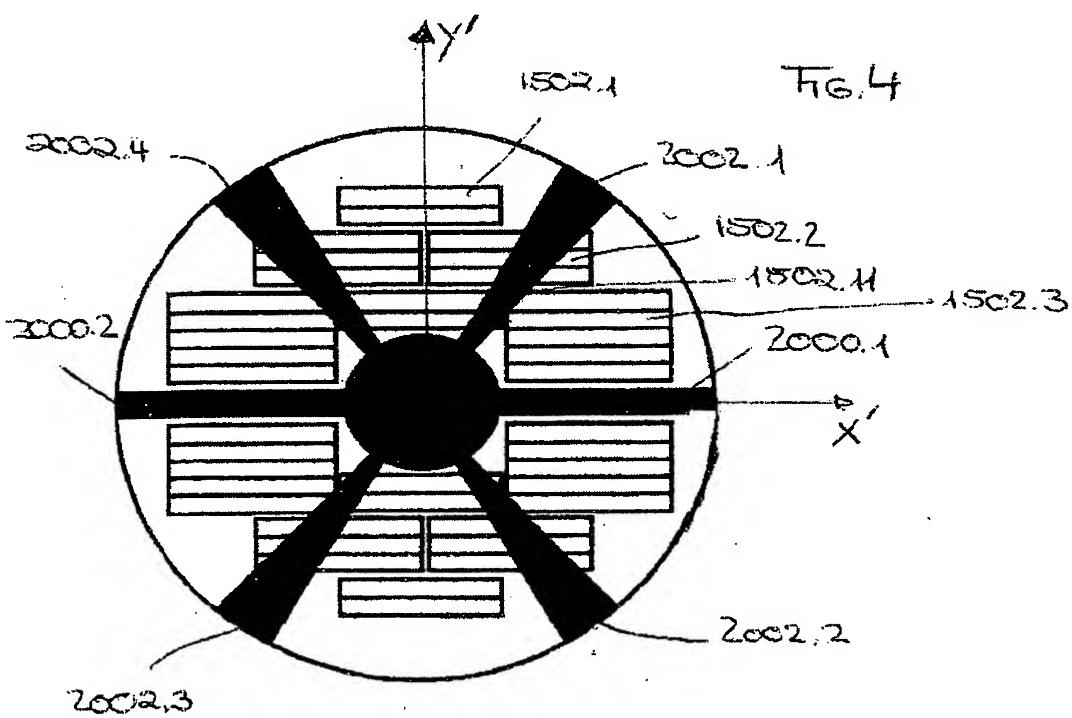
Fig.2





y
1500
1502.1
1502.10
1502.2
1502.11
1502.9
1502.3
x
1502.8
1502.4
1502.12
1502.5
1502.7
1502.6
1504

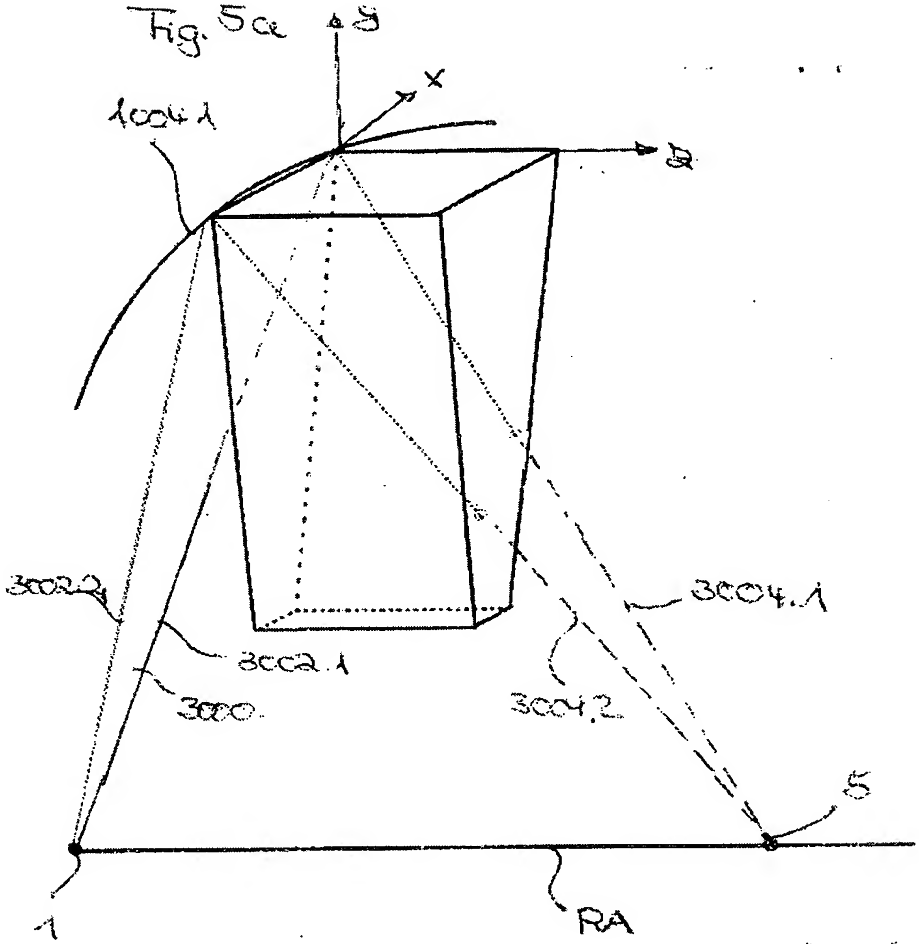
FIG.3



y'
1502.1
2002.4
2002.1
1502.2
1502.11
1502.3
2000.2
2000.1
x'
2002.2
2002.3

FIG.4

Fig. 5a



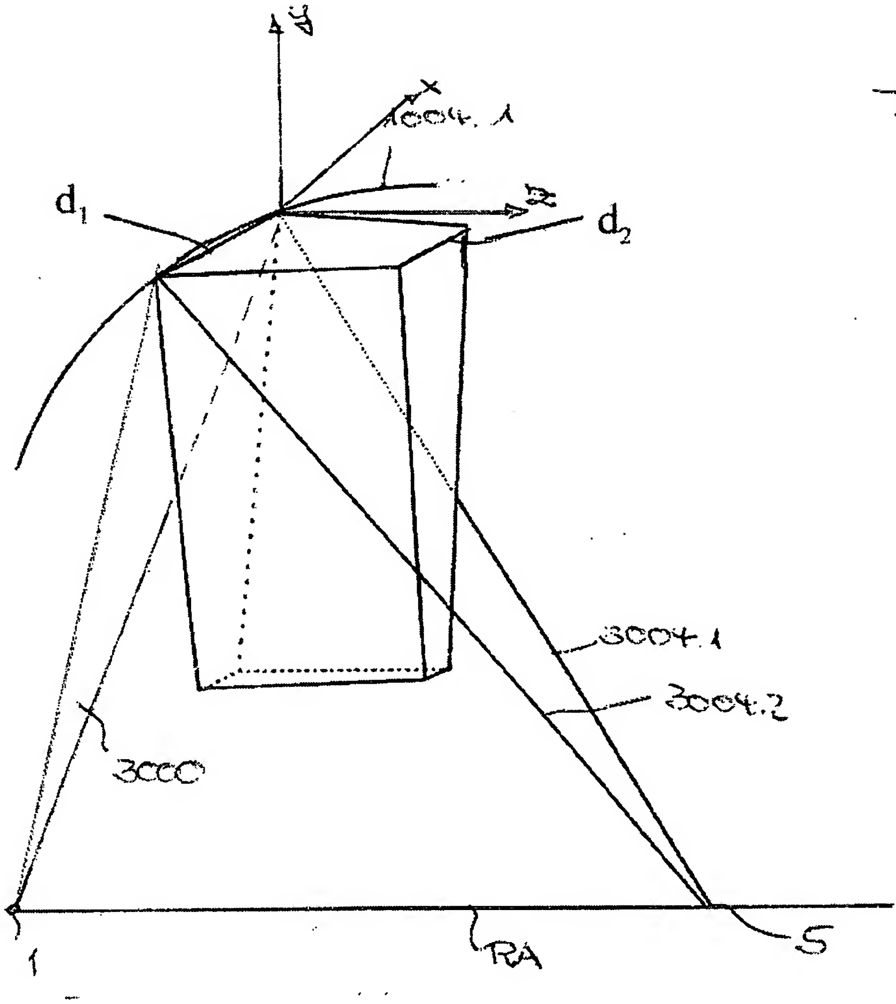
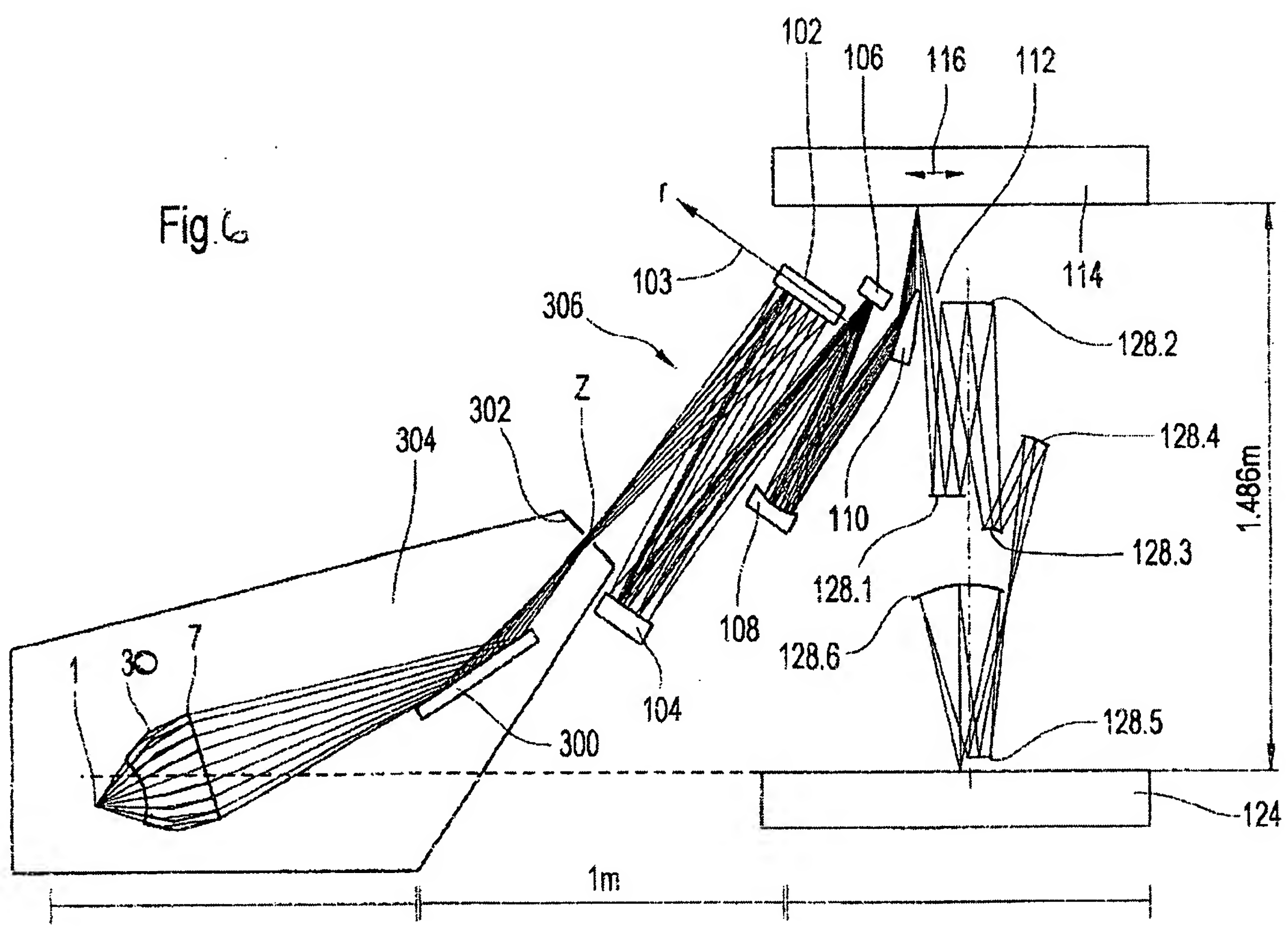


Fig. 5B

Fig. 6



102
106
116
112
r
103
114
306
128.2
302
Z
304
128.4
1.486m
110
128.3
128.1
108
128.6
1
30
7
104
300
128.5
124
1m

Fig. 7

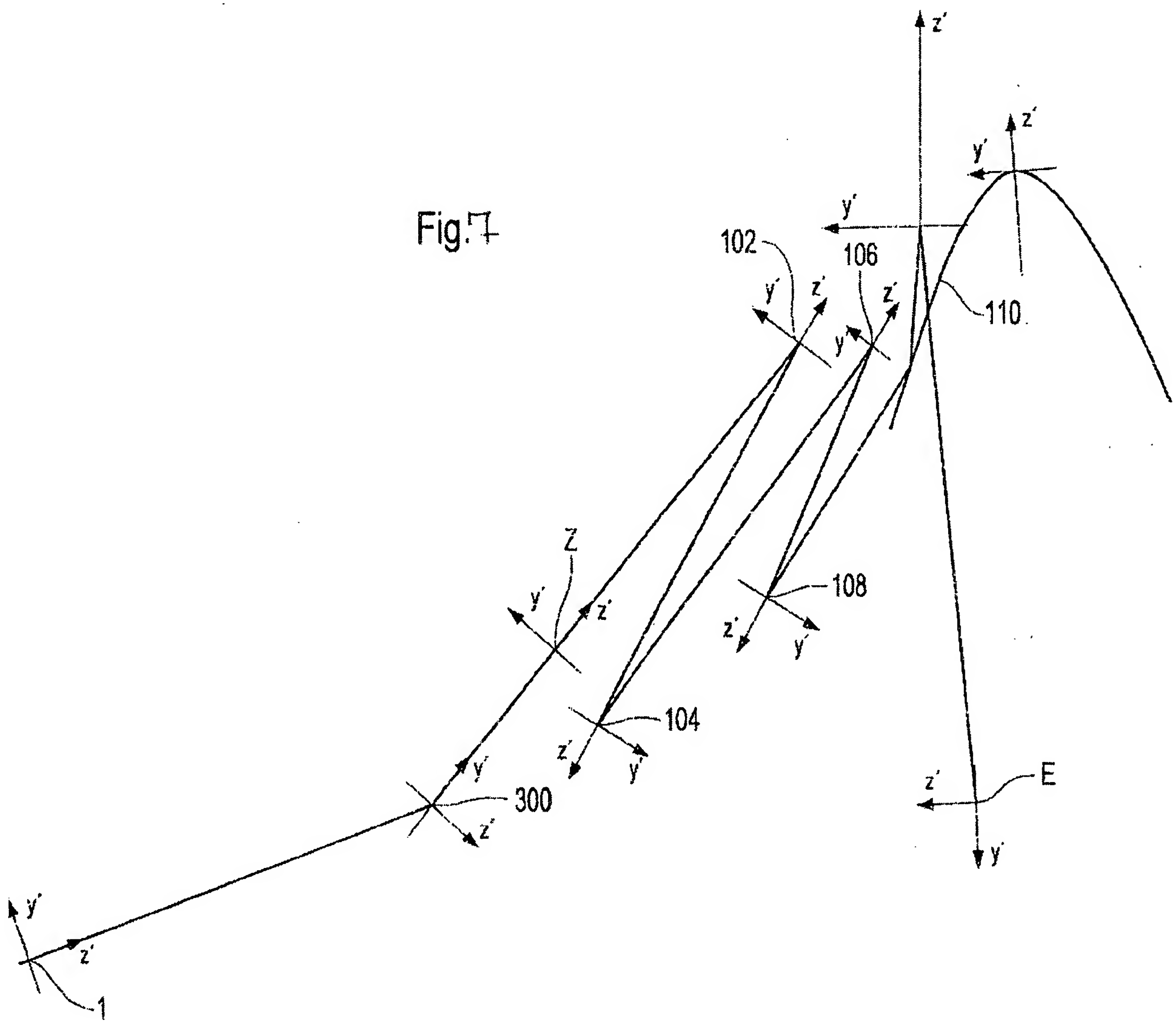


Fig.8

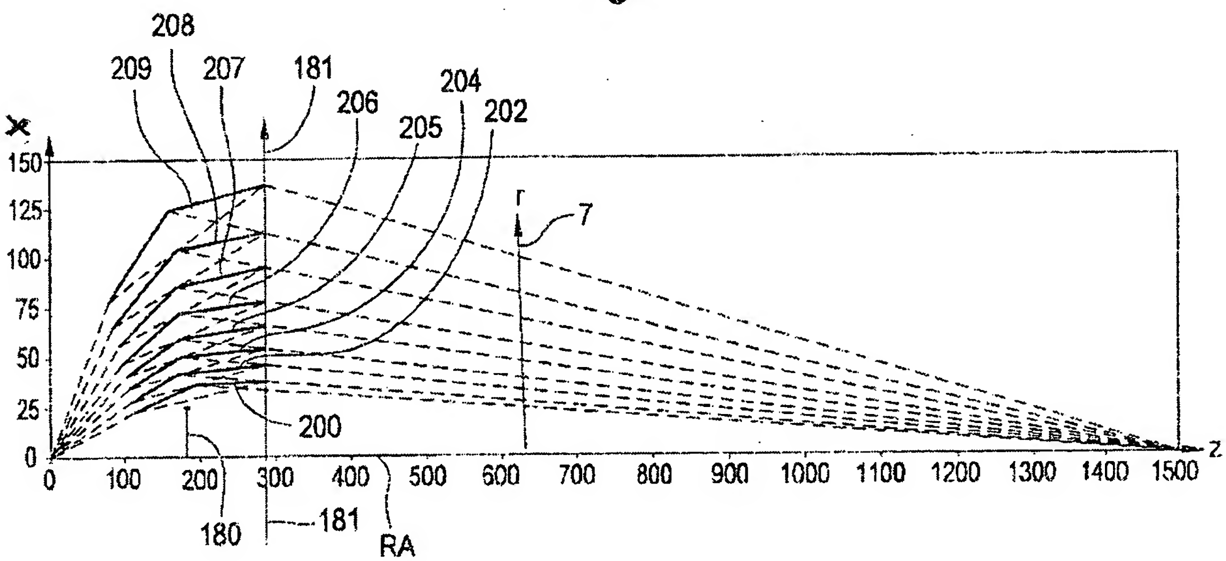

208
209
207
181
206
204
205
202
x
150
125
100
75
50
25
0
7
200
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
z
180
181
RA

Fig.9

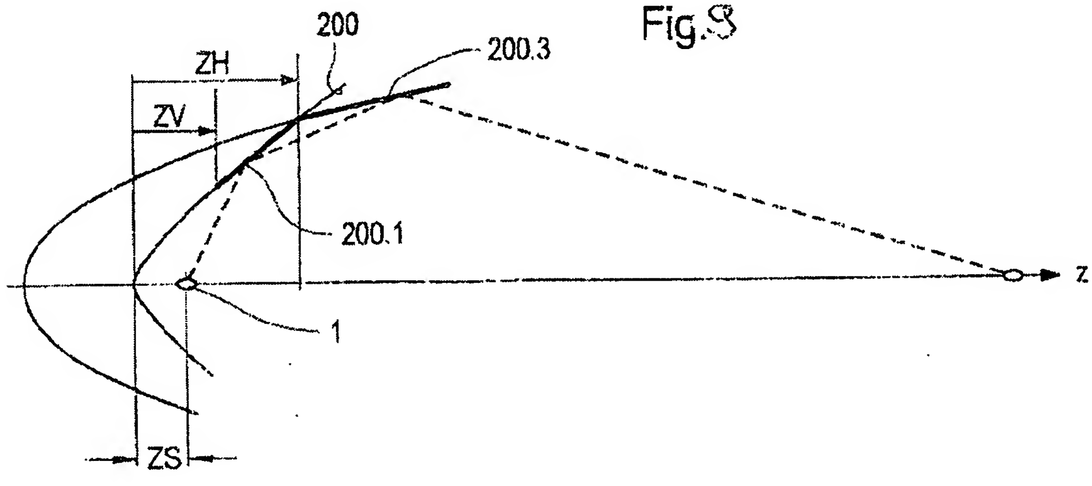
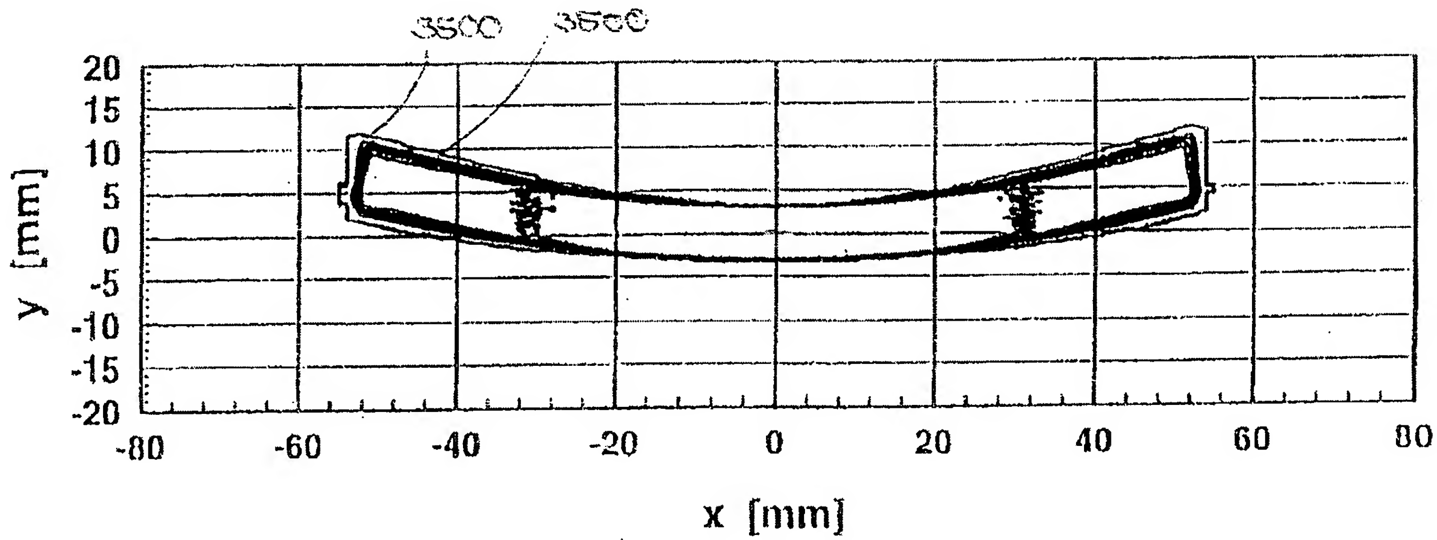

200
200.3
ZH
ZV
200.1
z
1
ZS

FIG. 10



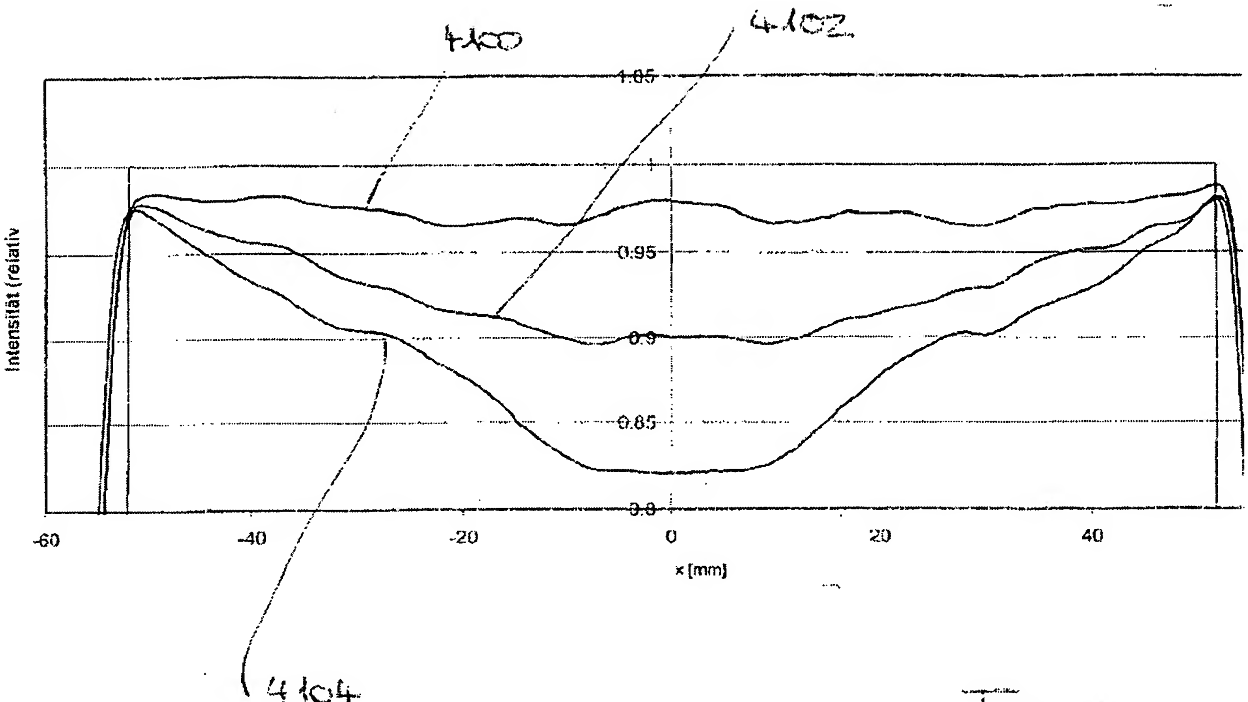

4100
4102
4104
1.05
1
0.95
0.9
0.85
0.8
Intensität (relativ
-60
-40
-20
0
20
40
x [mm]

FIG. 11

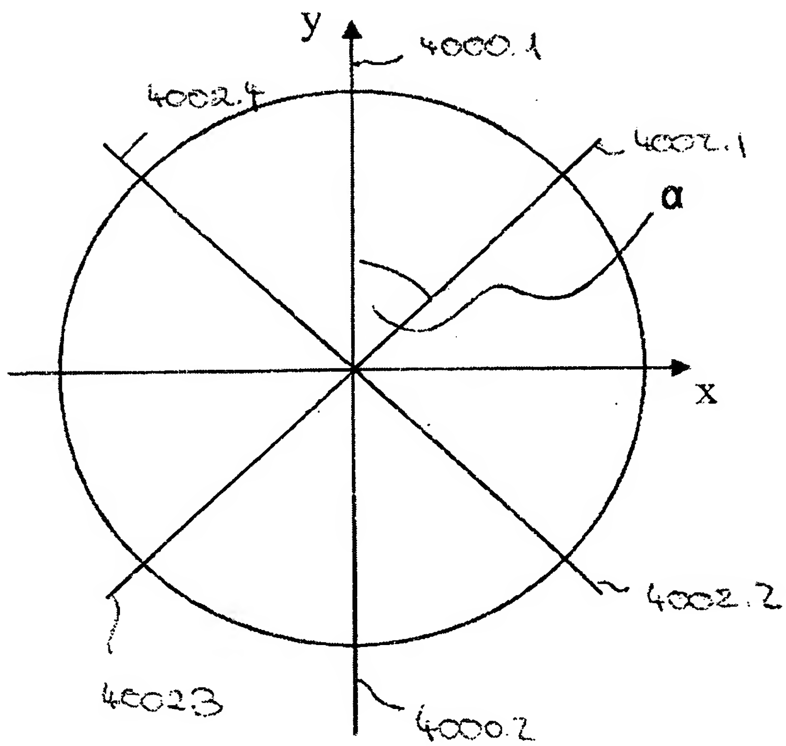


Fig. 12a

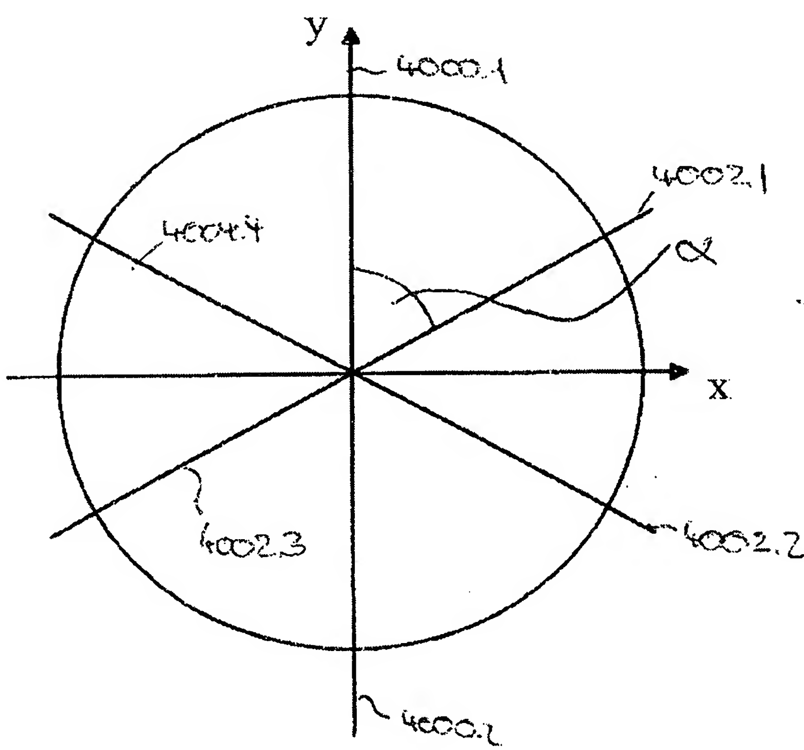


Fig 12b

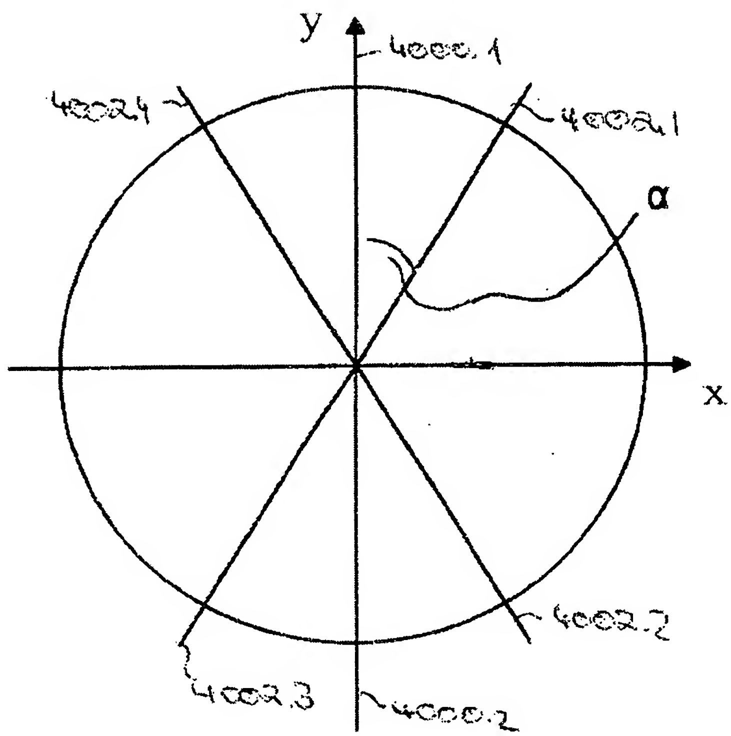


Fig 12a